

The "Simplest Transverter"

Check out the 6 meter band with this inexpensive 2 meter interface.

by Bob Witmer W3RW

Interested in trying a new band at minimum expense? Here's a receiving and transmitting converter (transverter) that requires no operating power (other than local oscillator DC) or T/R switching for operation, and will provide a minimum communications capability for checking out a new band such as 6 meters using a 2 meter transceiver.

While checking out the latest Mini-Circuits Labs catalog I was impressed by a new family of low-cost, high-level double-balanced mixers (DBMs): TUF-1H, TUF-2H and TUF-3H. With this in mind I decided to see how simple a transverter could be made. To simplify the design, I selected operation using the 6 and 2 meter bands and a 90 MHz LO. The high level DBM provides a useful output power level even though it is still on the low side (but not as low as the output of a standard level DBM, which is approximately 20 times lower). In addition, the transverter will work with FM, SSB and CW modes.

What is it? Well it really is nothing more than a high-level double-balanced mixer (DBM) with an attenuator on the transceiver side, an output low-pass filter on the antenna side, and a local oscillator (see Figure 1).

As mentioned before, this approach is practical because the high-level DBM's linear power capability goes all the way to 25 milliwatts. Without the need for any additional power (other than the local oscillator) you can get an output that is approximately 5 milliwatts—the actual power depends on a variety of factors. Measured transverter output using a HP 431D power meter was 5.1 milliwatts at 52.29 MHz. The other mixer characteristic that makes the simplest transverter possible is the DBM's bidirectional capability: The RF and IF ports can be interchanged, allowing mixer operation to

occur in either direction.

Five milliwatts—you've got to be kidding! Now, before you laugh too much about that power level, consider that one well-known popular 2 meter hand-held transceiver has a 100 milliwatt low power position (one new 2 meter transceiver even has a 20 milliwatt position!) and that when used with the normally supplied inefficient "rubber-duck" antenna, which typically has anywhere from a 6 to 10 dB loss factor relative to a dipole, the resulting radiated power could be on the order of 10 to 25 milliwatts—only several dB higher than 5 milliwatts. In addition, since the free-space line-of-sight path loss at 53 MHz is approximately 9 dB less than the loss at 146 MHz, if that 5 milliwatts is connected to a dipole or better equivalent antenna, communications similar to low power 2 meter hand-held operation is possible. This power level should make the FCC happy!

Receive Performance

If the transverter is used with a 2 meter transceiver with a 500 mW low power output, a 13 dB attenuator is needed on the input to limit the power to the linear operating range of the DBM. In this case, the total loss during receive is the conversion loss of the DBM—7 dB, plus the 13 dB loss of the attenuator pad for a total loss of 20 dB—equivalent to reducing the signal to 1/10 of its value. If your 2 meter receiver sensitivity is 0.2 μ V then a 20 dB loss in front of the receiver will be equivalent to using a 2.0 μ V receiver—which is not really all that bad considering the stations you can work using a 5-milliwatt!

In actual practice I've had QSOs on simplex and through several local 6 meter repeaters using only 2 milliwatts—approx-

mately half as much power! In all honesty, my signal was noisy, but it was fully intelligible.

My antenna is a Cushcraft Ringo at 25 feet, fed through about 30 feet of RG-8/U. Considering the simplicity of the transverter, the performance was surprising! If you operate CW or SSB, greater performance will be obtained. Figure 2 shows the transverter losses during transmit and receive.

How It Works

Receive: During receive, 6 meter antenna signals are connected via the low-pass filter to the DBM, where they are mixed with the 90 MHz local oscillator injection. The transverter acts as a typical receive converter. The local oscillator's output passes through the input attenuator to the 2 meter rig.

Transmit: The 2 meter rig's low power transmit signal is fed through the attenuator, where it is reduced to a level acceptable to the DBM and passed to the DBM. The 2 meter signal is mixed in the DBM with the 90 MHz LO creating outputs in the 6 meter band and in the 230 MHz region. The output of the DBM is connected to the low-pass filter, which passes the 6 meter signal and attenuates the 230 MHz output and any 2 meter and local oscillator signal feed-through.

Detailed Operation Description

The following sections provide a detailed description of the transverter's operation and refer to Figure 3, the schematic diagram.

Input Attenuator: The input attenuator of the transverter was designed for a 1/2 watt 2 meter power level, using approximate resistor values from the ARRL Handbook's 50 ohm resistive attenuator table, to provide ap-

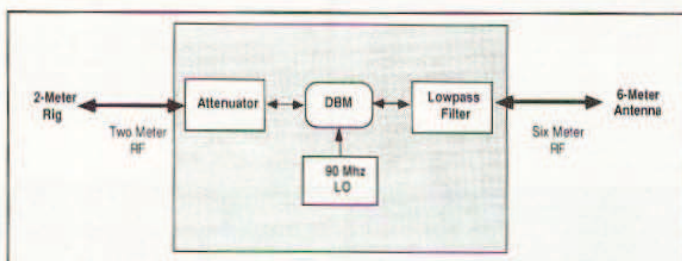


Figure 1. Simplest Transverter diagram.

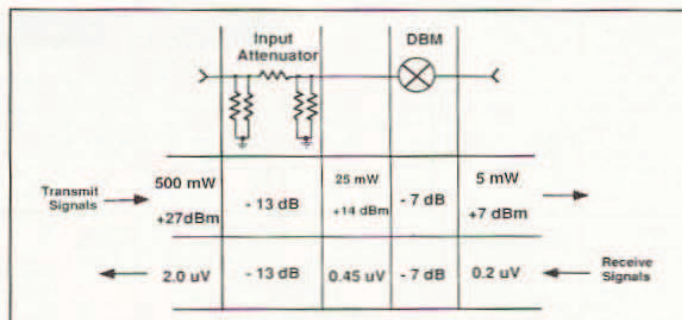
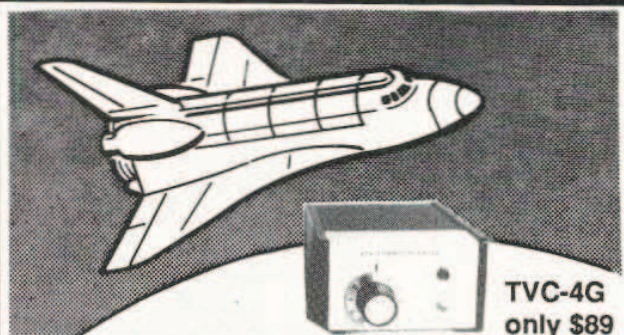


Figure 2. Transverter section loss diagram.

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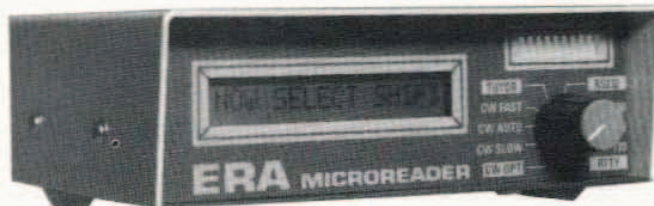
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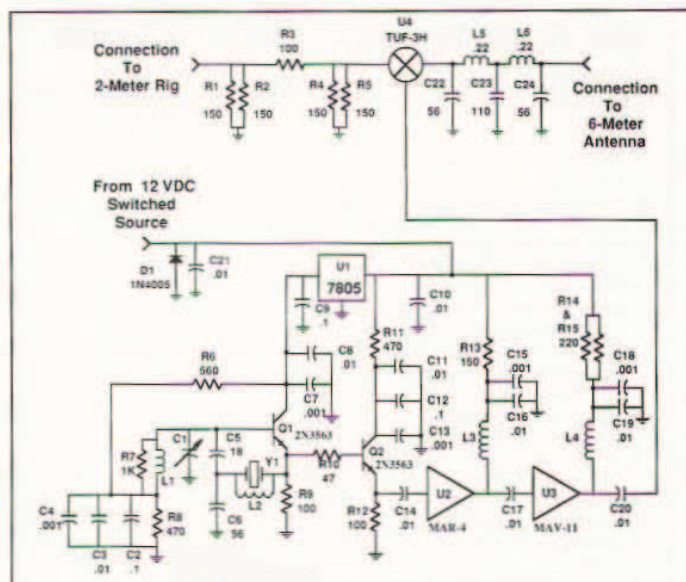


Figure 3. Simplest Transverter schematic.

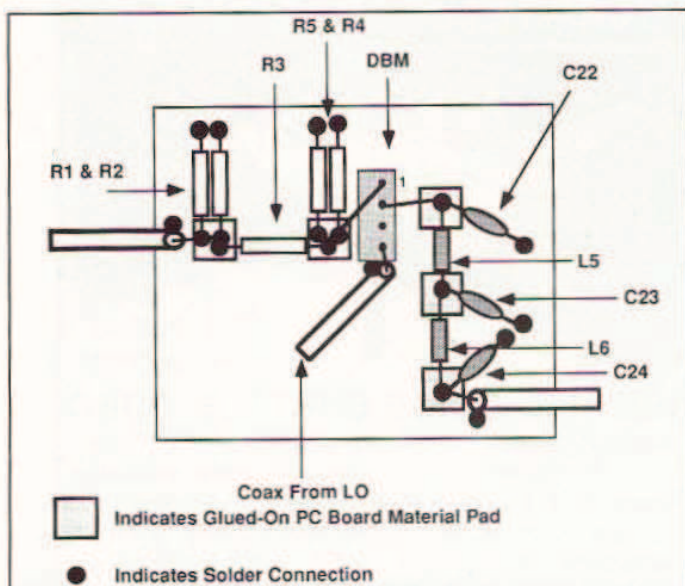


Figure 4. Approximate layout of mixer/filter board (not to scale).

proximately 13 dB of attenuation. This reduces the 1/2 watt to the recommended maximum linear rated input of the DBM, 25 mW. The input and output sections of the attenuator are made up of two paralleled 150 ohm 1/2 watt resistors.

Mixer: As mentioned before, the transverter takes advantage of the DBM's bidirectional performance characteristic. The DBM's ports are matched to the appropriate frequency range sections of the transverter. The IF or lowest frequency port (Pin 2) is used as the 6 meter port. The LO output is connected to the "LO" port (Pin 4) and the 2 meter side is connected to the "RF" port (Pin 1). Pin 3 of the DBM is connected to case ground and does not need a separate connection if the case is grounded.

Local Oscillator: The 90 MHz local oscillator circuit is adapted from the July 1989 *QST* article, "A Clean, Low-Cost Microwave Local Oscillator," by Richard Campbell. Mini-Circuits Labs MAR-4 and MAV-11 MMICs are used to provide the +14 to +17 dBm injection needed for high-level DBM operation. The circuit will "free" oscillate with a 47k resistor in place of the crystal and L2. This can be used to get the oscillator L1 and C1 components on

frequency to insure crystal oscillation. L1 is non-critical. One approach is to experiment until you get a coil that gives you the desired frequency oscillation range when tuned with C1. When the free-run frequency tuning range covers the crystal frequency, remove the 47k resistor and install L2 and the crystal, then adjust C1 for reliable starting and fine frequency trimming.

Local Oscillator Frequency Selection

FM & Repeater Band Segment Operation:

A 90 MHz 5th overtone crystal, Y1, was chosen for the oscillator so that the receive range for 53 to 54 MHz would convert to 143-144 MHz to simplify frequency read-out. Many of today's 2 meter rigs will operate, or can be modified for full operation, down to 142 MHz, permitting this approach. If your rig will

not make this range, I would recommend using a 93 MHz crystal. This will convert the active 6 meter repeater output section of the band (usually the lower half of the 53.01 to 53.97 MHz range) to the repeater input/simplex section of the 146 to 147 MHz band.

CW & SSB Band Segment Operation: Operating the Simplest Transverter with a 94 MHz oscillator will translate 144 MHz to 50 MHz for weak signal work but would convert the 6 meter repeater outputs to the low end of the 147 to 148 MHz range—the repeater output

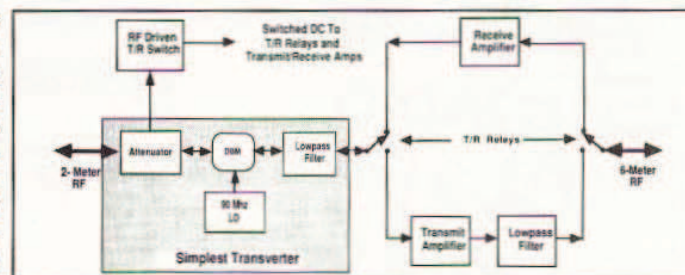


Figure 6. Upgraded Simplest Transverter diagram.

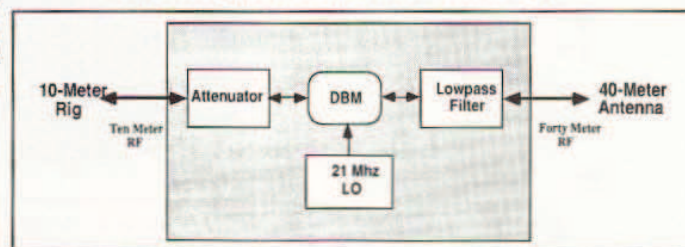


Figure 7. Simplest Transverter diagram for 10/40 meter operation.

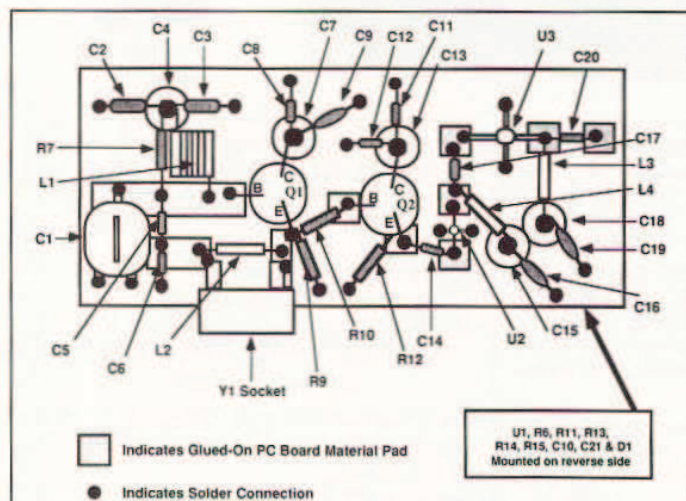


Figure 5. Approximate layout of the local oscillator board (not to scale).

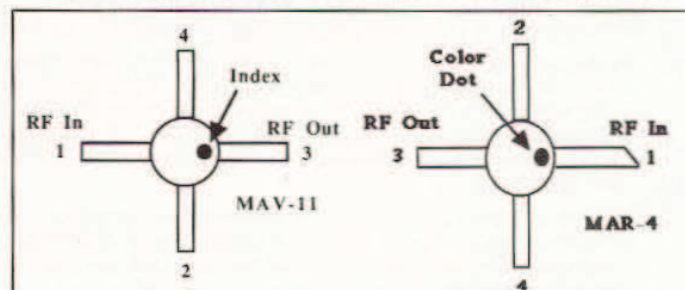


Figure 8. Pin identification of the MAV-11 and MAR-4 MMICs.

section of the 2 meter band. Local 2 meter repeater signals are often strong enough that some bleed-through is noted during base operation with an outside antenna if you use this frequency plan.

Output Filter: Because of the translator's frequency plan and the low output power level, filtering requirements are not severe. The 6 meter side of the DBM is connected to a five-section low-pass filter (L5, L6 C22, C23 and C24) whose values were selected from the five-element low-pass filter table in the *ARRL Handbook*, targeted at a 3 dB corner at 60 MHz with 20 dB attenuation at 83 MHz and 40 dB at 125 MHz.

Construction, Check-Out and Operation

The Simplest Transverter was constructed in two parts to simplify assembly and check-out—the input attenuator/DBM/output low-pass filter and the local oscillator. Both were assembled by gluing small pieces of single-sided board material, cut to the size required for the connection pads, onto a double-sided G-10 circuit board where desired. If a change is required, you can pry the desired pad loose and glue it in the new location. Grounding is accomplished by soldering directly to the ground plane—keeping the RF circuit ground leads as short as possible. Feed-through bypass capacitors are used for bypass requirements and DC power distribution is done on the opposite side of the board. Figures 4 and 5 show approximate layouts.

As mentioned before, local oscillator operation can be checked with a broadcast FM radio. With the LO operating, the transverter can be used as a receive converter for initial check of operation. An FM broadcast receiver (tuned to the second harmonic) can also be used to monitor the output of the transverter during transmit.

When operating with the transverter, use your 2 meter rig just as you normally would (in low power position). Program CTCSS and repeater split parameters as required if repeater operation is intended.

Higher performance can be achieved by adding receiver and transmit amplification stages to the transverter. Figure 6 shows one way that this could be accomplished.

Other Bands

The Simplest Transverter approach can be applied to other frequency band combinations. One example of this is shown in Figure 7, where the Simplest Transverter approach is used to provide 40 meter capability using a 10 meter transceiver. Of course, the input attenuator value and the low-pass filter characteristics must be adjusted, as required, for different power levels and operating frequencies.

Only slightly more complex than a receive converter, the Simplest Transverter provides about the simplest way to obtain operation on 6 meters with a 2 meter rig—any mode. This same approach can be used to obtain similar results on other ham bands.

Many thanks to all those who've had their ears abused by my noisy signals during QSOs while checking out the ability to conduct practical communications with milliwatt level transmit power.

Part

C1
C2,C9,C12
C3,C8,C10,C11,C14,C16,C17,
C19,C20,C21
C5
C6
C4,C7,C13,C15,C18
C22,C24
C23
D1
L1
L2
L3,L4
L5,L6
R6
R7
R8,R11
R9,R12
R10
R3
R1,R2,R4,R5,R13
R14,R15
Q1,Q2
U1
U2
U3
U4
Y1

Transverter Parts List Description

2-10 pF ceramic trimmer or equivalent
0.1 µF disc ceramic capacitor, 16-20 volts
0.01 µF disc ceramic capacitor, 16-20 volts
18pF NPO ceramic capacitor, 16-20 volts
56 pF NPO ceramic capacitor, 16-20 volts
0.001 µF feedthrough
56 pF miniature silver-dipped mica
100 pF miniature silver-dipped mica
1N4005 silicon diode
5 turns no. 28 enameled wire, 0.1" i.d., 0.2" long
0.33 µH miniature RF choke
0.33 to 1.6 µH miniature RF choke
0.22 µH air-wound or toroid coil—or miniature choke
560 ohm 1/4 watt carbon film resistor
1,000 ohm 1/4 watt carbon film resistor
470 ohm 1/4 watt carbon film resistor
100 ohm 1/4 watt carbon film resistor
47 ohm 1/4 watt carbon film resistor
100 ohm 1/2 watt carbon film resistor
150 ohm 1/2 watt carbon film resistor
220 ohm 1/2 watt carbon film resistor
2N3563, 2N5179—NPN transistor or equivalent
7805 or equivalent 5 volt regulator
Mini-Circuits Lab MAR-4 MIMIC amplifier
Mini-Circuits Lab MAV-11 MIMIC amplifier
Mini-Circuits Lab TUF-2H double-balanced mixer (also 3H & 1H)
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